Deformation-Enhanced Element Mobility in Feldspar: A Strain Speedometer?

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Hypotheses
1. Deformation enhances diffusion in minerals. 2. This enhancement varies systematically with strain for a variety of elements. 3. The differences in concentration contrasts measured in zoned plagioclase across a strain gradient can be compared to infer a duration of deformation and estimate strain rate.

Geologic Setting
Oriented samples were taken along two strain gradients in the outer and oldest unit of the Lower Cretaceous San José pluton, Peninsular Ranges batholith. This tonalite pluton experienced solid-state deformation during subsequent pluton emplacement. Plagioclase-dominated rheology and simple deformation history make it an ideal location to investigate element mobility in feldspar. (Overview maps modified from Johnson et al. and satellite image Digital Globe/GoogleEarth 2014.)

Approach
I will measure element concentrations across zoning at each strain increment, illustrated here for undeformed (dark blue) and intermediate and high strain (light blue). When elements with different diffusion coefficients are compared (for example Ca and Ba), their diffusion paths can be modeled to calculate a duration of diffusion equivalent to the age of the crystal. If deformation enhances element mobility, then deformed crystals will appear older. We interpret this difference as the duration of deformation.

Strain Gradient
Phenocrysts rare, mostly unzoned Recrystallized quartz and microgranular plagioclase in microshears White-mica-filled fractures Foliations

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Trends toward edge of pluton
- Grain size of all minerals decreases
- Plagioclase and quartz in deformed samples have undulose extinction
- Plagioclase phenocrysts lose their zonation and decrease in size and abundance
- Biotite increasingly but incompletely overprints hornblende and associated magmatic fabric
- Plagioclase develops a strong shape-preferred orientation

Remaining Challenges
- How do I translate this qualitative strain gradient into a quantitative strain metric for feldspar at the mineral scale?
- What are the best strain markers to use?
- Plagioclase dominates the San José tonality, but how much bulk strain does it accommodate (represent?)

References

Acknowledgements
Thanks to Field Bureaus and Field Groups and field assistant Matt Pauley. This project is funded by NSERC (Van Hinsberg and Rowe), QJERT (Rowe), GREAT (Barker), and a Robert Wann Fellowship.

References

Field photos oriented to show strike and thin section and sample scans oriented to show dips of fabric and foliation (c-axis are foliation-perpendicular, lineation-parallel when present).